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May 13, 2005

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SUBJECT: Final Technical Progress Report  
ONR Grant Number N00014-02-1-0812  
" Shark Attack Project - Marine Attack at Towed Hydrophone Arrays "  
Principal Investigator: Dr. Adrianus J. Kalmijn

Enclosed is the final technical report with an SF298 for the above referenced grant.

Sincerely,

A handwritten signature in dark ink, appearing to read 'April Fink', written over a horizontal line.

Mrs. April Fink  
Contract and Grant Administrator

Enclosures

cc: SIO Contracts and Grants, M/C 0210

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# **Shark Attack Project - Marine Attack at Towed Hydrophone Arrays, N00014-02-1-0812 Final Report, by Dr. Ad. J. Kalmijn, Principal Investigator**

## **Introduction**

The original objective of the SIO Marine Attack project was to identify the electric and magnetic fields causing sharks to inflict serious damage upon the towed hydrophone arrays of US Navy submarines. In contrast to the geophysical arrays that we studied concurrently, the US Navy's arrays appeared to be electromagnetically very quiet by proper design. The only galvanic fields we measured were those of some set screws of a dissimilar metal than the seawater-exposed titanium parts and those of the titanium parts themselves, especially when scratched or abraded during employment. Those fields will evoke bites from sharks coming close to their sources, as we proved in behavioral experiments. Much more serious fields are the image fields of the arrays in the electric fields due to oceanic and ionospheric circulations. Since the latter fields can not be removed, we have added to the original project the innovative objective of designing weak counter fields to divert or utterly confuse any sharks coming near the arrays. While further studies in our Electromagnetic Research Facility and tests at sea to determine the efficacy of the counter fields were in progress, the project was abruptly canceled at the moment of breakthrough success for reasons unknown to us.

## **Objectives met during first two years of three-year effort**

- To identify the electric and magnetic fields produced by the towed hydrophone arrays of US Navy submarines, by physical measurement in our research facility.
- To determine the propensity of the measured array fields to attract sharks and cause them to bite the arrays, in behavioral experiments on captive sharks.
- To recommend engineering means and measures to remove the sources of the offending electric and magnetic fields produced by the arrays.
- To design, by use of our computer multipole approach algorithm, weak-electric counter fields to divert or utterly confusing the animals.

## **Objectives met during remainder of effort**

- To study the linear-dipole image fields that the hydrophone arrays produce in the oceans' environmental electric fields, by physical measurement in our facility.
- To determine their propensity of soliciting shark bite as a function of the ambient field strength and the diameter of the arrays.

## **Recommendations for further work**

- It is strongly recommended, actually strictly necessary, to test the efficacy of the counter fields in experiments at sea. We have already received the ok to explore the feasibility of such work in the Sea of Cortez, which we successfully did.

## **In summary**

The project as conducted thus far has met, and even exceeded, the original expectations of success. Given the opportunity of bringing the project to completion, we had expected to pay our dues worth many times the costs of repair and idle time that we will spare the US Navy, and to prevent potential disaster as for the US submarines and their crews during critical missions. Fortunately, the science we had hoped to conduct has been extremely successful, so that we have no regrets, even though the cancellation came as a great surprise to our team.

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